Fish diets and food webs in the Northwest Territories: brook stickleback (*Culaea inconstans*)

D.B. Stewart, T.J. Carmichael, C.D. Sawatzky,
N.J. Mochnacz, and J.D. Reist

Central and Arctic Region
Fisheries and Oceans Canada
Winnipeg, MB R3T 2N6

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FISH DIETS AND FOOD WEBS IN THE NORTHWEST TERRITORIES: BROOK STICKLEBACK (*Culaea inconstans*)

by

D.B. Stewart[1], T.J. Carmichael, C.D. Sawatzky, N.J. Mochnacz, and J.D. Reist

Central and Arctic Region
Fisheries and Oceans Canada
501 University Crescent
Winnipeg, Manitoba
R3T 2N6

[1] Arctic Biological Consultants, 95 Turnbull Drive, Winnipeg, MB, R3V 1X2

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ABSTRACT

Stewart, D.B., Carmichael, T.J., Sawatzky, C.D., Mochnacz, N.J., and Reist, J.D. 2007. Fish diets and food webs in the Northwest Territories: brook stickleback (*Culaea inconstans*). Can. Manuscr. Rep. Fish. Aquat. Sci. 2798: iv + 17 p.

The brook stickleback is a low to mid-level omnivore that inhabits cool, clear, littoral habitats of streams and lakes. Adults and juveniles eat a wide variety of seasonally available invertebrate taxa of various life stages that originate mostly from aquatic habitats. These small fish are eaten by a variety of large invertebrates and small vertebrates, and will eat their own eggs. Northern pike (*Esox lucius*) and smallmouth bass (*Micropterus dolomieu*) may be able to extirpate them from small ponds and lakes. This document provides a generalized food web for the brook stickleback, and reviews knowledge of its interactions with predators, prey, and competitors. Dietary differences related to geographical location, habitat type, life history stage, season, predation, and competition are discussed.

Key words: diet; life history; habitat use; fresh water; lacustrine; feeding behaviour; riverine; Gasterosteidae.

RÉSUMÉ

Stewart, D.B., Carmichael, T.J., Sawatzky, C.D., Mochnacz, N.J., and Reist, J.D. 2007. Fish diets and food webs in the Northwest Territories: brook stickleback (*Culaea inconstans*). Can. Manuscr. Rep. Fish. Aquat. Sci. 2798: iv + 17 p.

L'épinoche à cinq épines est un omnivore qui se situe à un niveau trophique faible à moyen. Elle habite les eaux littorales fraîches et limpides des ruisseaux et des lacs. Les adultes et les juvéniles se nourrissent d'une grande variété d'invertébrés se présentant selon les saisons et les stades de vie, d'origine principalement aquatique. Ce petit poisson est consommé à son tour par une gamme de grands invertébrés et de petits vertébrés. Par ailleurs, il mange ses propres œufs. La prédation exercée par le grand brochet (*Esox lucius*) et l'achigan à petite bouche (*Micropterus dolomieu*) peut l'amener à disparaître des petits étangs et des lacs. Nous présentons un réseau trophique généralisé pour cette épinoche et nous évaluons les connaissances sur ses interactions avec ses prédateurs, ses proies et ses compétiteurs. Nous examinons également les différences dans son alimentation reliées aux emplacements géographiques, aux types d'habitat, aux stades du cycle vital, aux saisons, à la prédation et à la compétition.

Mots clés : régime alimentaire; cycle vital; utilisation d'habitat; eau douce; lacustre; comportement alimentaire; fluvial; Gastérostéidés.

1.0 INTRODUCTION

Renewed interest in natural gas pipeline development along the Mackenzie Valley has raised the prospect that fish species in the watershed may be impacted by changes to their habitat. The proposed pipeline would extend from near the Beaufort Sea coast to markets in the south (http://www.mackenziegasproject.com/). Fishes in the Mackenzie River depend upon the integrity of their aquatic habitats, so it is important to summarize knowledge that can be used to assess potential impacts of this development proposal and others, and to facilitate efforts to avoid and mitigate these impacts.

This report reviews knowledge of the diet of the brook stickleback, *Culaea inconstans* (Kirtland, 1840), a small fish (≤ 87 mm) with protective spines that is widely distributed in cool, clear waters of north-central North America and in the Northwest Territories occurs along the length of the Mackenzie River mainstem from Tsiighetchic south (Scott and Crossman 1973; Lee *et al.* 1980; Stewart *et al.* 2007).

Riverine[1] and **lacustrine** life histories have been observed among brook stickleback populations (McPhail and Lindsey 1970; MacLean and Gee 1971; Scott and Crossman 1973; Nelson and Paetz 1974, 1992; Wootton 1976; McKinnon and Hnytka 1979; Lee *et al.* 1980; Moodie 1986; Stewart *et al.* 2007). The species inhabits a wide variety of flowing water habitats, including rivers, streams, and **ephemeral** streams and ditches. It also inhabits lakes, spring fed ponds, beaver ponds, seasonal meltwater ponds, potholes, sinkholes, and hotsprings. Shallow (<1.5 m), well-vegetated (>60% cover) shorelines with low water velocity and soft substrates provide particularly important spawning, feeding, and rearing habitats for the brook stickleback. While primarily a freshwater species, it is occasionally found in brackish water. Individuals have been caught at elevations from sea level along the Hudson Bay coast (Baker 1989) to ~2,400 m above sea level (asl) in Wyoming (Quist *et al.* 2004). Stewart *et al.* (2007) provide a recent review of habitat use by the brook stickleback.

Few brook sticklebacks have been captured in the Northwest Territories and little is known of their diet or life history in the region. This limits assessments of the effects of environmental changes on the species. This report presents a generic food web for the brook stickleback, based largely on data from outside the Northwest Territories, and discusses how it may be applied to brook stickleback populations in the Northwest Territories. It reviews knowledge of how the species' diet varies with geographical location, habitat type, season, life history stage, and competition. It also considers predation pressures and identifies knowledge gaps. Similar reports have been prepared for other fishes that inhabit the Mackenzie River watershed.

[1] Terms in bold type are defined in the Glossary.

2.0 FOOD WEB

Quantitative data from brook stickleback populations in the Northwest Territories, Manitoba, and Alberta (Appendices 1 to 3) were used to construct a generic food web (Figure 1). Few quantitative studies were found and most of the sampling was conducted during the open water period. This limits comparisons of dietary differences among populations in different regions and habitat types, and what can be said about the general energetic importance of each pathway.

The methods used to quantify brook stickleback diet were not directly comparable among the studies reviewed. Some studies quantified the taxa in the stomach contents using % by volume, while others used a proportion or % by number. To facilitate rough comparisons among studies, proportions were converted to percentages before their inclusion in the Appendices. Aspects of the brook stickleback food web, including predators and dietary differences related to life history stage, habitat, and season are discussed below, as are the effects of inter- and intraspecific competition.

2.1 Predators

Brook sticklebacks are eaten by a variety of large invertebrates, fishes, mammals, and birds. However, because of their small size, protective spines and armour plates, and well-developed predator avoidance behaviour, they are usually only a minor prey item (Winn 1960).

Large aquatic insects will eat brook sticklebacks (Reist 1980b; Zimmerman 2006). In the laboratory, adult water bugs (*Lethocerus americanus*), dragonfly nymphs (*Aeschna* spp.), and water beetle larvae (*Dystiscus* spp.) all preyed successfully on these fish, but only at night (Reist 1980b). The nymphs of other dragonfly species (F. Aeshnidae - darners), including *Anax junius*, *Basiaeshna janata*, and *Boyeria vinosa* also eat sticklebacks (Zimmerman 2006). Aggressive protection by nesting male sticklebacks likely limits egg predation by invertebrates.

Many fish species eat brook stickleback larvae and/or adults. Fish predators include: yellow perch (*Perca flavescens*), rock bass (*Ambloplites rupestris*), creek chub (*Semotilus atromaculatus*), burbot (*Lota lota*) (Zimmerman 2006), central mudminnow (*Umbra limi*) (Moodie 1977; Zimmerman 2006), smallmouth bass (*Micropterus dolomieu*) (MacRae and Jackson 2001), largemouth bass (*Micropterus salmoides*) (Hoyle and Keast 1987), northern pike (*Esox lucius*) (Beaudoin *et al.* 2001), brook trout (*Salvelinus fontinalis*) (Ricker 1930), rainbow trout (*Oncorhynchus mykiss*) (Tavarutmaneegul 1978) and round goby (*Neogobius melanostomus*) (Thomas 1997). Brook stickleback eggs

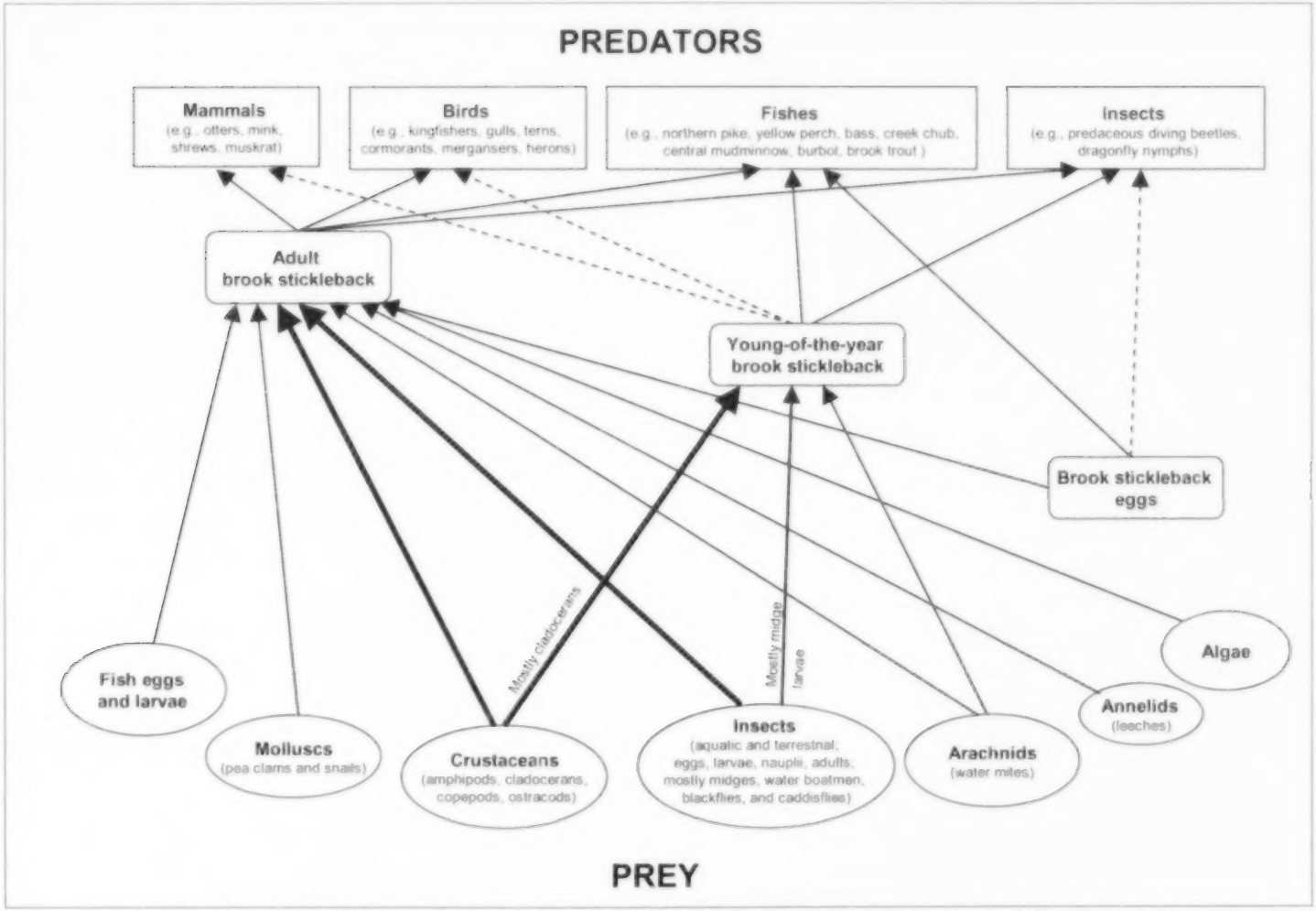

Figure 1. Generalized food web for the brook stickleback showing the direction of energy flow. Bold lines indicate major food pathways, in comparison to thinner lines; solid lines indicate demonstrated pathways and dashed lines indicate putative pathways.

are eaten by rainbow trout (Tavarutmaneegul 1978), and are also cannibalized by brook sticklebacks (Moodie 1986). The complete list of fishes that prey upon the brook stickleback is likely much longer than that presented here.

Fish species assemblages in ponds and lakes of the Athabasca watershed in Alberta typically lack brook stickleback if northern pike are present, probably due to predation by the pike (Robinson and Tonn 1989). Northern pike that are >85 mm in length will eat brook sticklebacks (Beaudoin *et al.* 2001). In the laboratory, small pike (18-27 mm SL; SL = **standard length**) show preference for sticklebacks that lack pelvic spines, but these spines may not confer protection against predation by larger pike (Reist 1980a). Yellow perch are also important predators of brook sticklebacks but, unlike northern pike, do not appear to eliminate them from lakes (Robinson and Tonn 1989; Reed 2002)

Smallmouth bass predation has reduced abundance, altered habitat use, and extirpated brook stickleback and other small-bodied fish species in various Ontario lakes (MacRae and Jackson 2001). Brook stickleback populations exposed to predation by central mudminnow showed a reduction in body size (Moodie 1977). This may be a response to the removal of larger individuals or to foraging in suboptimal habitat to avoid predation.

In Manitoba, creek chub in the Mink River fed selectively on brook sticklebacks in early summer (Newsome and Gee 1978). Later in the season the growth of aquatic vegetation may provide cover for brook sticklebacks, causing a switch in prey selection. Stickleback exposed to chub predation in the Mink River had shorter lifespans, larger eggs, and greater fecundity than those in the Drifting River, which were not exposed to predation by chub (Weselowski 1974). The extent to which these observations are related to differences in habitat productivity is unknown.

Brook stickleback was the most frequently encountered food item in the scats of mink (*Mustela vison*) and otter (*Lutra canadensis*) from headwater drainage systems of the Athabasca River in Alberta (Gilbert and Nancekivell 1982). Brook stickleback remains made up the majority of the total scat sample for otters in both lake (72.1%) and stream habitats (63.6%). The scat samples (498 otter, 311 mink) were collected from April to November, but likely represent prey species consumed over a full calendar year. Muskrat (*Ondatra zibethicus*) and shrews (F. Soricidae) will also eat brook sticklebacks (Coad 2005).

Bird predators of the brook stickleback include the belted kingfisher (*Megaceryle alcyon*) (Sayler and Lagler 1949), laughing gull (*Larus atricilla*), common tern (*Sterna hirundo*) (Pope 1909), and double-crested cormorant (*Phalacrocorax auritus*) (Trapp *et*

al. 1998). These fish are also likely eaten by mergansers (*Mergus* spp.), herons (F. Ardeidae) (Scott and Crossman 1973), and many other piscivorous birds.

Their morphological and behavioural adaptations to avoid predation may allow brook sticklebacks to efficiently exploit habitats that contain predators (Abrahams 1995). These adaptations may also make them less vulnerable to predation by introduced species, compared with sympatric species that lack these adaptations. Within populations, individuals with defensive pelvic spines may be more likely to escape from predators once they are captured, while those that lack these spines have better startle responses and may be more likely to avoid capture (Andraso and Barron 1995; Andraso 1997). Brook sticklebacks learn to recognize unfamiliar predators quickly by observing the fright responses of members of their own or other species that are familiar with these predators (Mathis *et al.* 1996).

When predation risk is high, brook stickleback tend to associate with unarmoured species such as the fathead minnow (*Pimephales promelas*) (Mathis and Chivers 2003). Yellow perch attack minnows in these mixed shoals earlier, and more often, than they do the sticklebacks. Fathead minnows are also more vulnerable to predation by northern pike than are brook sticklebacks (Robinson and Tonn 1989). In feeding experiments, minnows were more efficient foragers than sticklebacks, so it should benefit sticklebacks to avoid minnows unless predation risk is high (Mathis and Chivers 2003).

2.2 Prey

The brook stickleback is a low to mid-level omnivore (Stewart and Watkinson 2004). It eats algae and vascular plant material (Robinson 1972) but is mostly carnivorous, preying upon aquatic insect larvae, adult terrestrial insects, crustaceans, fish eggs and larvae, snails, oligochaetes, nematodes, rotifers, and mites (Robinson 1972; Scott and Crossman 1973; Wootton 1976; McKinnon and Hnytka 1979; Tompkins and Gee 1983; Moodie 1986). Individuals exhibit a flexible foraging behaviour that enables them to optimize their foraging efficiency in response to prey distribution and abundance (Tompkins and Gee 1983). Dietary differences among brook sticklebacks at different life history stages, in lake or stream environments, and during the year are discussed below.

Newly hatched brook stickleback **fry** eat primarily planktonic crustaceans and dipteran larvae in both lake (Robinson 1972) and stream habitats (McKinnon and Hnytka 1979; Tompkins and Gee 1983). Brook sticklebacks <35 mm SL, typically juveniles, eat many small organisms, while larger fish eat a mixture of large and small organisms. These differences are likely related to mouth size, not distribution (Robinson 1972). Fish infected with the trematode parasite *Schistocephalus solidus* are generally

found near the surface, so they eat more plankton and fewer benthic biota than do uninfected fish.

Dietary changes during the open water period are related to differences in the relative availability of prey species (Robinson 1972). In Astotin Lake, Alberta, chironomid larvae, amphipods, cyclopoid nauplii, and ostracods were important foods throughout the late April through mid-October study period (Robinson 1972). The occurrence of leeches, ceratopogonid larvae, and algae in the diet decreased as summer progressed, while that of cladocerans, corixids, and water mites increased. Trichopteran larvae, pelecypods, and gastropods were only eaten in late summer and early autumn. Mosquito eggs and larvae were eaten in sequence, dysticid larvae were only eaten for a short period, and fish eggs were eaten during the spawning period. Detritus was found in the stomachs throughout the study period, but sand only in late summer and early autumn. Few of the fish examined from Astotin Lake, Alberta, in winter had food in their stomachs (Kaminski 1977).

In the Rennie River, Manitoba, the mean feeding index (i.e., the wet weight of food in the stomachs/total body weight x 100) increased from 1.0 in April to 1.8 in June, and then decreased progressively to 0.1 in winter (December to March) (Tompkins and Gee 1983). Sixty percent of the brook sticklebacks collected in winter had empty stomachs.

During the year, brook sticklebacks in the Rennie River fed between dawn and sunset, with the greatest intensity between 1200 and 2000 h (Tompkins and Gee 1983). Comparison of the stomach contents with possible prey items in the environment showed that they selected certain taxa, including chironomid larvae, Sididae and Bosminidae, and particular size classes within taxa. Fish in their first year selected smaller items than older fish, and both age groups ate smaller prey than they were morphologically capable of handling.

During the spawning season of some years, cannibalized eggs accounted for over half the weight of the stomach content of adult brook sticklebacks in a small prairie pothole where other fish species winterkill (Moodie 1986). This may account for a significant percentage (estimated at 16.7%) of the annual egg production, particularly when population densities are high and/or food production is low. Males will eat eggs they have fertilized (Salfert and Moodie 1985).

2.3 Competitors

Growth of the brook stickleback may be sensitive to both intra- and interspecific competition (Abrahams 1996; Gray and Robinson 2002). The length, weight, and condition of brook sticklebacks in prairie potholes may be related to population density

(Moodie 1986). They also grow less in the presence vs. absence of ninespine stickleback (Gray and Robinson 2002). When the two species were kept together *in situ*, **allopatric** forms of the brook stickleback had lower growth than **sympatric** forms, suggesting that the latter have adapted to reduce interspecific competition. Competition is reduced when the species are sympatric, because brook sticklebacks occupy the **littoral** and ninespine sticklebacks the **pelagic** zone (Moodie 1977).

The diet of brook sticklebacks is more diverse in the presence of fathead minnows (*Pimephales promelas*), which are generalist feeders (Abrahams 1996). In the absence of fathead minnows, brook sticklebacks ate mostly copepods, whereas in their presence they ate higher proportions of cladocerans, ostracods, and dipteran larvae. In laboratory studies when the species were tested separately, fathead minnows ate a wider variety of zooplankton, while all age classes of sticklebacks showed strong selectivity for *Daphnia* (Laurich *et al.* 2003).

3.0 SUMMARY

The brook stickleback is a low to mid-level omnivore that occurs in a wide variety of cool, clear freshwater stream and lake types, and will venture into warmer ephemeral habitats to spawn in the spring. Shallow (<1.5 m), well-vegetated (>60% cover) shorelines with low water velocity and soft substrates provide particularly important spawning, feeding, and rearing habitats for this species. Throughout its distribution, both adults and juveniles eat a wide variety of seasonally available invertebrate taxa of various life stages (eggs, larvae, pupae, nauplii, adults) that originate mostly from aquatic habitats. Fish in their first year select smaller items than older fish, and both age groups eat smaller prey than they are morphologically capable of handling. Brook sticklebacks will eat their own eggs and are eaten by a variety of large invertebrates, fishes, mammals and birds. The species' morphology and behavioural adaptations to predation, may allow it to efficiently exploit habitats that contain predators. However, northern pike and smallmouth bass may be able to extirpate the brook stickleback from small ponds and lakes. Competition for food with minnows and ninespine sticklebacks may limit the growth of brook sticklebacks in some lake habitats.

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6.0 GLOSSARY

Allopatric species do not inhabit the same waterbody.

Ephemeral stream or pond habitats only contain water for a short period each year, typically during the spring when they receive meltwater runoff, or later after heavy rains.

Fry are young fish, newly hatched, after yolk has been used up and active feeding has commenced.

Lacustrine populations live and grow in lakes or ponds (i.e., lacustrine habitats).

Littoral habitats are near the shore.

Pelagic habitats within a waterbody are not near the bottom or shore.

Riverine populations live and grow in streams or rivers (i.e., riverine habitats).

Standard length (SL) is the distance from the tip of the snout to the base of the caudal fin rays.

Sympatric fish species inhabit the same waterbody.

7.0 APPENDICES

Data are presented in Appendix 1 on the seasonal stomach contents of young-of-the-year and adult brook sticklebacks from the Rennie River, Manitoba; in Appendix 2 on the prey of brook sticklebacks in lakes; and in Appendix 3 on their prey in tributary streams of the Liard River, Northwest Territories.

Key to Appendices 2 and 3:

+ = present in small amounts.
0 = present in the waterbody but not found in the diet.
P = present in the diet but not quantified.
* = these species were eaten by sticklebacks in other areas of Astotin Lake, Alberta (Robinson 1972).
** = fish are considered to be age 0, or young-of-the-year (yoy), until December 31 of the year they are hatched.

References:

1 = Abrahams 1996
2 = Held and Peterka 1974
3 = Kaminski 1977
4 = Robinson 1972 (Residence Point area)
5 = Moodie 1986
6 = McKinnon and Hnytka 1979

Notes:

a = % composition by number.
b = % volume points.

Appendix 1. Seasonal stomach contents of young-of-the-year and adult brook sticklebacks in the Rennie River, Manitoba (50°07'16"N, 95°37'48"W) (% composition by number; from Tompkins and Gee 1983). See above for explanatory key.

	Young-of-the-year (Age 0)**				Adult (Age 1)**							
Month	Jul	Aug	Sept	Oct	Apr	May	Jun	Jul	Aug	Sep	Oct	Winter (Dec-Mar)
# of stomachs examined	≥ 15	≥ 15	≥ 15	≥ 15	≥ 25	≥ 25	≥ 25	≥ 15	≥ 15	≥ 15	≥ 15	≥ 25
Ph. Arthropoda												
Cl. Insecta (insects)												
O. Diptera (gnats, mosquitoes, flies)												
F. Chironomidae (midges)--larvae	29.2	19.8	22.7	36.9	38.1	31.0	12.1	36.2	35.8	26.8	26.1	54.7
F. Simuliidae (blackflies, gnats)						18.3	0.8					
SubPh. Crustacea												
SubO. Cladocera (water fleas)	38.9	59.5	51.0	41.1	0.2	9.8	28.2	46.7	43.4	49.5	29.2	7.7
Cl. Maxillopoda												
SubCl. Copepoda	11.0	11.4	14.4	14.2	48.2	25.3	30.2	7.7	7.8	11.5	36.9	34.7
Cl. Ostracoda	7.1	5.9	7.2	0.5	0.5	8.0	20.8	4.7	4.5	4.7	1.1	2.9
Other invertebrates	13.8	3.4	4.7	7.6	13.0	7.6	7.9	4.7	8.5	7.5	7.4	

Appendix 2. Prey of brook sticklebacks in lakes. See above for explanatory key.

	Astotin Lake, Alberta				Lake Manitoba, Manitoba	"Lake 200", Manitoba	Wildlife Lake, North Dakota
Season	Apr-Sep	Apr-Sep	Apr-Sep	Feb-Mar	Jul-Sep	May-Sep	Jun,Aug,Nov
Coordinates		53°41'N, 112°51'W			51°05'N, 98°47'W	50°30'N, 100°10'W	?
Elevation (m asl)							
Life history type	Lacustrine	Lacustrine	Lacustrine	Lacustrine	Lacustrine	Lacustrine	Lacustrine
Life stage (J = juvenile; A = adult)	J	A,J ?	A	A	J	A,J	A?
Age range** (yoy = young-of-the-year)	yoy				yoy		
Length range (mm)	<20 mm SL	<35 mm SL	>35 mm SL				
# of stomachs examined (# empty)	18	103	250	50(most)	5		30
Plants			0.13				
Algae		1.56	0.13				
Invertebrates							
Ph Annelida							
SubCl. Hirudinea (leeches)			1.57				
Ph. Arthropoda							
Cl. Arachinda (arachnids, water mites)		0.66	0.26		P		
Cl. Insecta (insects)			1.95				
O. Coleoptera (beetles)							
F. Dytiscidae (predaceous diving beetles)			0.16 (larvae)				
O. Ceratopogonidae (biting midges)			P (larvae)*				
O. Diptera (gnats, mosquitoes, flies)					5 (larvae)		
F. Chironomidae (midges)	0.16 (larvae)	14.18 (larvae)	23.55 (larvae)			P (larvae, pupae, adults)	
F. Culicidae (mosquitos)		0.47 (eggs)	0.45 (eggs), P (adults)*				
F. Simuliidae (blackflies)							

O. Ephemeroptera (mayflies)							
O. Hemiptera (true bugs)							
F. Corixidae (water boatmen)		1.56	5.42				
O. Trichoptera (caddisflies)		1.56 (larvae)	2.21 (larvae)	P			
SubPh. Crustacea							
O. Amphipoda (e.g., *Gammarus*)		2.80	23.47			P	P
SubO. Cladocera (water fleas)	97.57	18.54	3.21	P	7	P	P
Cl. Maxillopoda							
SubCl. Copepoda	1.78 (cyclopoid nauplii)	47.37 (cyclopoid nauplii)	22.83 (cyclopoid nauplii)	P	65		P
Cl. Ostracoda	0.49	7.64	9.56		13		
Ph. Mollusca							
Cl. Bivalvia (clams)			0.32	P			
F. Pisiidea (pea clams; was F. Sphaeriidae)				P			
Cl. Gastropoda (snails)		0.23	0.42				
Fishes			0.64				
F. Gasterosteidae (sticklebacks)							
Culaea inconstans (brook stickleback)						P (eggs)	
Fish eggs			1.18				
Detritus			0.48				
Other items (sand + unidentified)		3.43	2.31		9		
Reference:	4	4	4	3	1	5	2
Notes:	b	b	b	b	a		

Appendix 3. Prey of brook sticklebacks in tributary streams of the Liard River, Northwest Territories. See above for explanatory key.

	unnamed creek (mile 38.5)	unnamed creek (mile 42.8)	unnamed creek (mile 43.8)	unnamed creek (mile 48.9)	unnamed creek (mile 115.7)
Season	Jul	Jul	Jul	Jul	Jul
Coordinates	61°19'30"N, 122°14'W	61°18'N, 122°23'W	61°16'N, 122°24'W	61°14'30"N, 122°32'30"W	60°29'N, 123°27'W
Elevation (m asl)	~190	~205	~190	~190	~265
Life history type	Fluvial	Fluvial	Fluvial	Fluvial	Fluvial
Life stage (J = juvenile; A = adult)	J	J	J	A	A
Age range** (yoy = young-of-the-year)	yoy	yoy	yoy		
Length range (mm)	23	25-30	20-32	49-78	54
# of stomachs examined (# empty)	1 (0)	7 (4)	5 (0)	6 (1)	1 (0)
Plants					
Algae					
Invertebrates					
Ph Annelida					
SubCl. Hirudinea (leeches)					
Ph. Arthropoda					
Cl. Arachinda (arachnids, water mites)		33.3			
Cl. Insecta (insects)					
O. Coleoptera (beetles)					
F. Dytiscidae (predaceous diving beetles)					
O. Ceratopogonidae (biting midges)					
O. Diptera (gnats, mosquitoes, flies)			6.1 (pupae)		11.1 (larvae)
F. Chironomidae (midges)			36.8 (larvae)	2.4 (larvae)	44.4 (larvae)
F. Culicidae (mosquitos)					
F. Simuliidae (blackflies)	58.3 (larvae)			3.5 (larvae)	
O. Ephemeroptera (mayflies)		66.7 (larvae)	0.4 (larvae)	94.1 (larvae)	4.44 (larvae)

O. Hemiptera (true bugs)					
F. Corixidae (water boatmen)					
O. Trichoptera (caddisflies)					
SubPh. Crustacea					
O. Amphipoda (e.g., *Gammarus*)					
SubO. Cladocera (water fleas)					
Cl. Maxillopoda					
SubCl. Copepoda	33.3		36.1		
Cl. Ostracoda	8.3		20.6		
Ph. Mollusca					
Cl. Bivalvia (clams)					
F. Pisiidea (pea clams; was F. Sphaeriidae)					
Cl. Gastropoda (snails)					
Fishes					
F. Gasterosteidae (sticklebacks)					
Culaea inconstans (brook stickleback)					
Fish eggs					
Detritus					
Other items (sand + unidentified)					
Reference:	6	6	6	6	6
Notes:	a	a	a	a	a